

## Appendix A – Software short manual

The `grid_strain` software easily analyzes GPS velocity defining the strain pattern within the studied area. Several routines estimate the elements of strain tensor over a regular grid, depending to the points distribution. Users can easily manage the program by means of a window cascade menu and graphical interfaces. The sequence for a correct execution is:

1) data logging; 2) data visualization and management; 3) grid creation and/or modification; 4) definition and/or change of the smoothing factor  $d0$ ; 5) strain tensor estimation and significance test execution; 6) tensor trace and maximum normalized shear computation.

*Data logging, visualization and management* – When the program starts, an interactive window menu appears and the user can choose to load a new data file. The ASCII-file data are loaded from the “*new calculation of both grid and strain*” option (figure A1). This file should contain 10 columns, that are, respectively, the station identifier, the east and north Cartesian coordinates, the components of velocity on the plane, the root mean square (*rms*) error of velocities and error ellipses together with their azimuth.

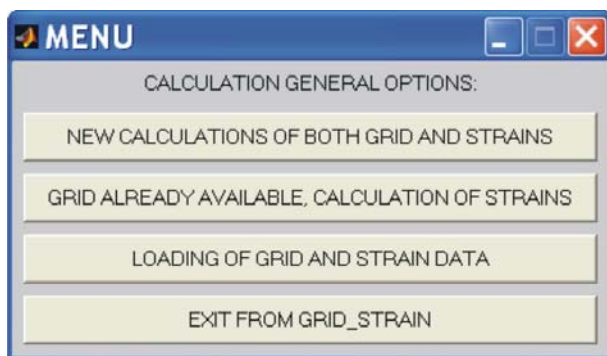


Fig.A1 – a) The first menu interface and Dialog box for ASCII filename inserting. In the example CAGeoNet velocity data are loaded.

The visualization is immediately performed and velocity vectors are plotted together with their error ellipses (fig.A2) in the *mat-figure* No.1.

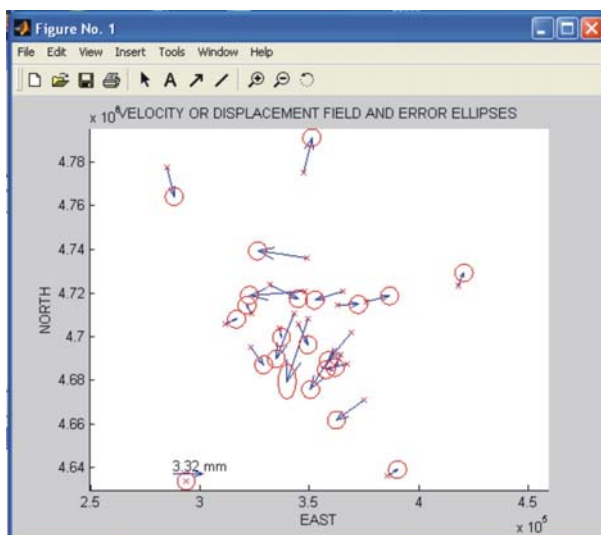


Fig.A2 – Velocities belonging to CAGeoNet network processing.

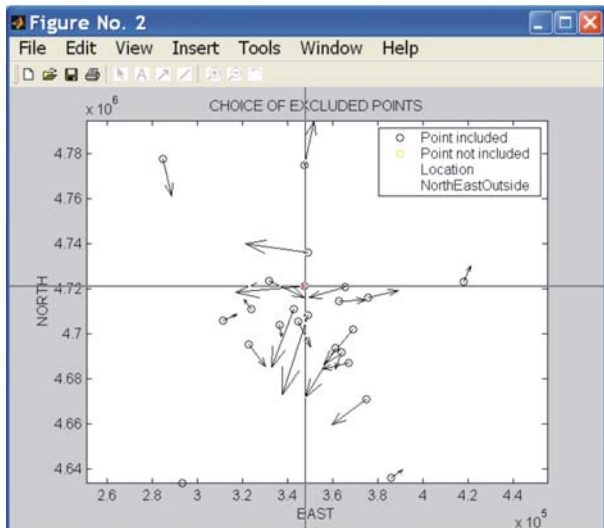


Fig.A3 – Interactive figure for eventual point removal.

It is possible to exclude one or more points from the strain computation using the pointer on the *mat-figure* No.2 (fig.A3). This operation can be executed more times.

*Grid definition* - The program automatically computes the grid length based on station baselines. The standard deviation of all the inter-distances between points is computed and proposed: the user can accept or refuse this default value, as shown in figure A4.

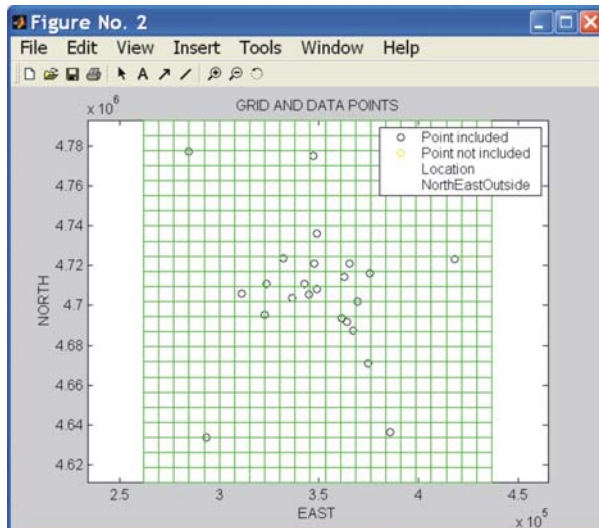


Fig.A4 – Automatic grid definition: a 7-km spacing was computed and the window for acceptance or modification of the grid.

Both the grid spacing and grid dimension can be modified, manually inserting more appropriate values into the blank spaces (the menu window, fig. A5). Moreover, the grid box can be interactively changed choosing different vertices on the figure, using the pointer.

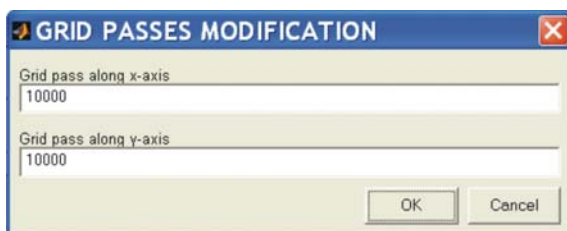


Fig.A5 – Manual change of grid spacing.

The program automatically computes a preliminary  $d0$  smoothing parameter as three times the grid spacing. It can be manually modified using a dialog box (fig. A6).

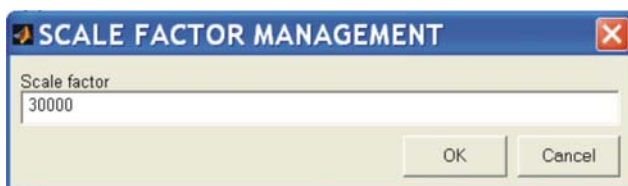


Fig.A6 – Manual definition of scale factor for weighting: the default value is three times the grid spacing.

The grid can be saved and successively loaded in another session by means of the option “*Grid already available, calculation of strains*” available in the menu. With the same interactive procedure shown in Fig. A3, in this case the user can remove some points or can reintroduce points excluded in the previous session.

*Strain computation over grid nodes* – The program starts the strain estimation over each node of the final defined grid. The computational functions to solve for the redundant equation system, estimating the velocity gradient tensor, follow the standard linear least square approach (Koch, 1988). The weight function for error scaling is also introduced at this stage. Moreover, a significance routine starts defining the points where results can be considered truly representative of a local strain at  $d0$  scale. The user can choose to plot results for the whole

grid area or to blank not significant data (fig. A6). Figure A7a shows results of strain tensor estimation over the grid nodes where the significance tests were passed successfully (fig. A7b).

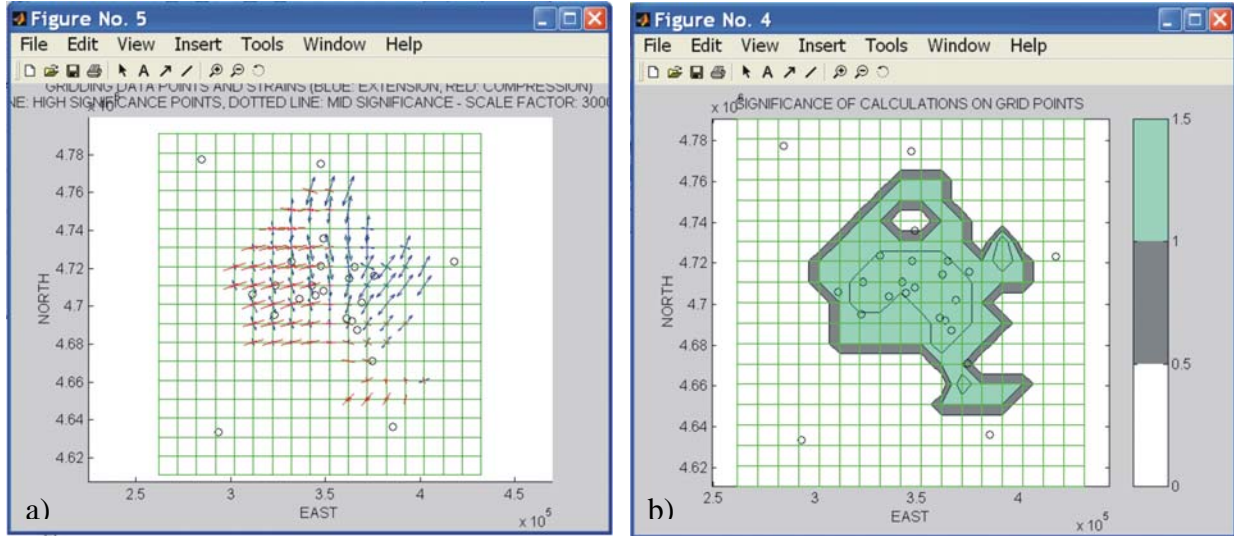


Fig.A7 – a) The strain rate tensor pattern and its variability b) Significant areas.

Finally, the program computes and displays automatically both the strain tensor trace ( $e_{\max} + e_{\min}$ ), and the normalized maximum shear ( $(e_{\max} - e_{\min}) / (e_{\max} + e_{\min})$ ) (Lay and Wallace, 1995). Once these computations and visualizations are done, the user can repeat the described procedure by changing the current parameters (for example  $d0$ ) and new graphics and new data are added and stored (fig.A8).

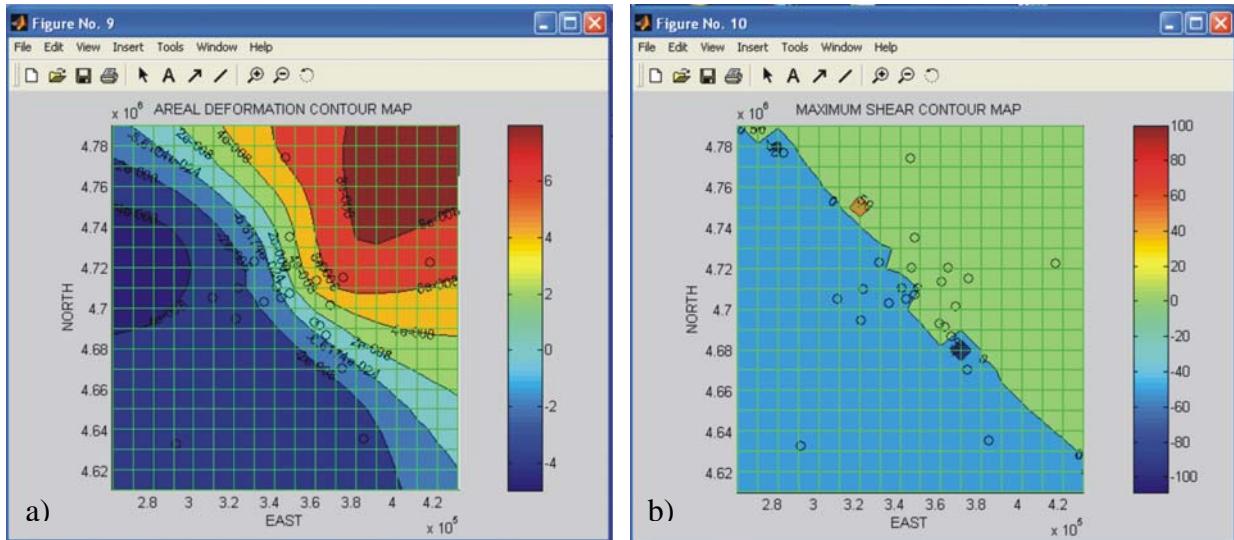


Fig.A8 – a) Trace of the strain tensors and its distribution in the investigated area; b) Maximum normalized shear trending.

The `grid_strain` software has a reasonable computational cost, considering the resources generally available. Nearly all the most expensive calculations are performed calling Matlab™ built-in functions (MathWorks, 2006); these functions are executable files with optimized algorithms; for example, sorting/searching procedures have  $O(N \log N)$  cost.

Only the strain calculations for each grid point requires a direct iterations on the grid matrix, but also in this case the CPU time is short. For example, dealing with CAGeoNet data, using the velocities of 23 stations, creating a 24x25 grid (600 nodes) with a pass of 7589 m, and choosing  $d0 = 22766$  m, the time involved for the complete execution of the strain calculation was 0.87 s, using a Intel™ Premium™ 4 521 Dual Core CPU with 2.8 GHz clock. The total time for a complete session, also including the manual data loading, is meanly 12 s.

All the functionalities of this program are guaranteed, dealing with Matlab™ 6.5 and newer versions.

## Appendix B – Maximum shear modified function

The normalized maximum shear function is defined and computed as  $(e_{\max} - e_{\min}) / (e_{\max} + e_{\min})$  and is characterized by a few properties (figure B1). The sign of the function is given by the sign of the greater eigenvalue in modulus. When  $|e_{\max}| \gg |e_{\min}|$  or  $|e_{\max}| \ll |e_{\min}|$  the function tends to  $\pm 1$  and reveals the predominance of one component over the other. On the contrary, if values are comparable and with the same sign, the function goes to  $\pm 0$  and diverges if the signs are opposite.

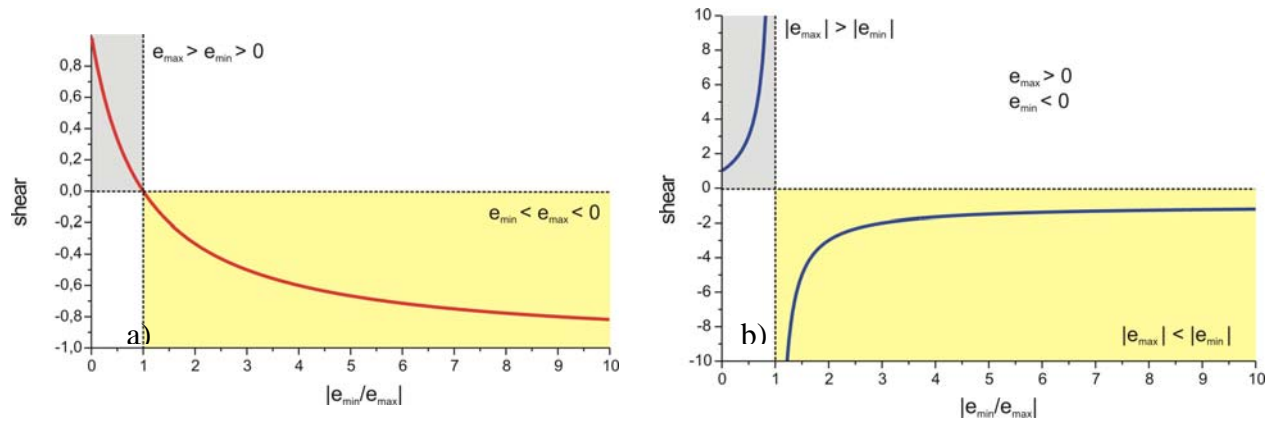


Fig.B1 – a) maximum normalized shear function for tensor characterized by the same compressive or extensional behavior along the principal axes; b) maximum normalized shear function for different signs.